We claim:

1. A system to determine and analyze the dynamic internal load in rotating mills, for mineral grinding, the system comprising:

(a) wireless acoustic sensing means to detect sound inside the mill during operation and attached to the shell or external casing of said revolving mill;

(b) synchronism sensing means to synchronize the revolving movement of the mill and

(c) processing and control means to:

(i) determine the load foot angle, corresponding to the estimated position where the lifters contact the load in motion;

(ii) determine the load shoulder angle, which corresponds to the location where the load or load cataract starts to fall towards the load foot; and

(iii) determine on-line the volumetric filling of the dynamic load, when the mill is operating.

2. The system of claim 1, wherein the rotating mill uses steel balls as a grinding means.

3. The system of claim 2, wherein the processing and control means further determines the volumetric filling of grinding balls.

4. The system of claim 3, wherein the processing and control means further determines the apparent density of the load.

5. The system of claim 4, wherein the synchronism sensing means is of an inductive type.

6. The system of claim 4, wherein the synchronism sensing means is of a capacitive type.

7. The system of claim 4, wherein the synchronism sensing means is of an optical type.

8. The system of claim 1, wherein the synchronism sensing means detects an element attached to the mill shell or outer body at each turn of the mill.

9. The system of claim 8, wherein said element attached to the mill shell is contained in at least one wireless acoustic sensing means.

10. The system of claim 9, wherein said at least one wireless acoustic sensing means are arranged in at least one group on the mill shell.

11. The system of claim 10, wherein said at least one wireless acoustic sensing means are arranged in two groups on the outer circumference of the mill shell, and are circumferentially spaced at about 180° from each other.

12. The system of claim 10, wherein at least one said wireless acoustic sensing means are arranged in three groups on the outer circumference of the mill shell, and are circumferentially spaced at about 120° from each other.

13. The system of claim 10, wherein at least one said wireless sensing means are arranged in three groups on the outer circumference of the mill shell, and are circumferentially spaced at about 90° from each other.

14. The system of claim 10, wherein each group is made up of at least one wireless acoustic sensor.

15. The system of claim 14, wherein each group is arranged on the mill shell according to its longitudinal axle.

16. The system of claim 15, wherein the wireless acoustic sensors are fed by a power supply connected to an external power supply that is used to recharge the battery cells once their capacity has exhausted.

17. The system of claim 16, wherein the external power supply is comprised of two independent charge circuits of the same number as the number of cells used, and has charge control by current, voltage, and maximum charge temperature and time protections.

18. The system of claim 16, wherein the charge system is internal and based on auto-generation, with an intermediate accumulator, through a pendulum-type generator and a dynamo, making use of the mill's revolving.

19. The system of claim 16, wherein the charge system is internal and based on auto-.generation, with an intermediate accumulator, through a pendulum-type generator and a dynamo making use of the induction from the magnetic field present around the mill, as a loop arrangement revolving along with the mill.

20. The system of claim 1, wherein the wireless acoustic sensing means further comprises a means of transmission to transmit a signal.

21. The system of claim 20, further comprising wireless receiving means for said signal.

22. The system of claim 21 wherein the processing and control means receive a signal from the receiving means and a signal from the synchronism sensing means, where the receiving means sends an analog signal to said processing and control means, which signal is received at an analog-to-digital signal converting unit; the synchronism sensing means generating a first

synchronism signal to determine the relative position of the wireless acoustic sensing means; the processing and control means receive said first synchronism signal from the synchronism sensor, which first synchronism signal is processed by a conditioning module that transmits a second synchronism signal to said analog to digital signal converting unit, that transmits a digital signal to a CPU that runs an input/output interface means necessary to allow bi-directional communication that may be either analog or digital, with the mill's control system.

23. The system of claim 22, further comprising display means allowing to view, in real time, the estimated values.

24. A method of determining and analyzing the internal dynamic load in revolving mills, for mineral grinding, said method comprising the following steps:

(a) detecting sound inside the mill, through wireless acoustic sensors attached to the shell of the revolving mill, to thereby provide a sound signal;

(b) providing a synchronism signal to synchronize the revolving motion of the mill; and

(c) processing said sound signal and said synchronism signal for:

(i) determining the load foot angle corresponding to the estimated position where the lifters contact the load in motion;

(ii) estimating the load shoulder angle corresponding to the position where the load or load cataract starts to fall toward the load foot; and

(iii) estimating, on-line, the dynamic volumetric load filling when the mill is operating.

25. The method of claim 24, wherein the revolving mill uses steel balls as grinding means.

26. The method of claim 25, wherein the processing step further includes the step of determining the dynamic volumetric filling of the grinding balls.

27. The method of claim 26, wherein the processing step further includes the step of dynamic volumetric mineral filling.

28. The method of claim 27, wherein the processing step further includes the step of estimating the apparent density of the load

29. The method of claim 28, wherein the step of providing a synchronism signal comprises the step of detecting an element attached to the mill shell each time that said mill turns one revolution.

30. The method of claim 29, wherein the sound detection step also comprises the step of transmitting said sound signal.

31. The method of claim 30, further comprising the step of receiving said sound signal and sending said sound signal as in said processing step.

32. The method of claim 31, wherein the processing step also comprises:

(iv) receiving said sound signal and said synchronism signal;

(v) generating a second synchronism signal to determine the relative position of the wireless acoustic sensing means installed on the shell of the revolving mill;

(vi) processing said signals in a analog-digital converter; and

(vii) transmitting a digital signal from said analog to digital converter to a CPU that runs an input/output interface necessary for bi-directional communication, that may be analog or digital, with the mill's control system.

33. The method of claim 32, further comprising a display step allowing the view, in real time, of the determined values.

34. The method of claim 24, wherein the step of determining the load foot angle comprises the following steps:

(i) analyzing the digital sound signals and the synchronism pulse temporarily to determine the sound portion corresponding to a full-turn of the mill plus the last fourth of the previous turn and the first fourth of the next turn, the first and last point of the resulting signal coming to zero, thus preventing the edge effects of the previous filtering process;

(ii) defining the zero reference of the angular position of the acoustic sensor based on said synchronism signal;

(iii) applying to the resulting signal a digital high-pass filter having a cut-off frequency at 2 or 3 Khz, of 6th order and with phase correction;

(iv) applying a phase correction through a double filter to the original signal and then another filter, with identical characteristics to the filtered signal, but reverting the direction of the signal;

(v) obtaining the envelope of the resulting signal, using a rectifying process (absolute value) and again filtering at low frequency;

(vi) finding in the envelope the maximum width, and

(vii) obtaining the relative angular position of the maximum found from the angular axis, being thus defined the absolute angular position of the load foot with respect to the mill's vertical.

35. The method of claim 24, wherein the step of determining the angle of the load shoulder comprises the steps of:

(i) temporarily analyzing the digital sound and synchronism pulse signals to determine the sound portion corresponding to a full turn of the mill plus the last fourth of the previous turn and the first fourth of the next turn, the first and last point of the resulting signal coming to zero, so as to prevent the edge effects of the previous filtering process;

(ii) defining the zero reference to the angular position of the acoustic sensor based on said synchronism signal;

(iii) applying to the resulting signal a digital band pass filter with cut-off frequencies between 180 and 400 Hz, of 6th order and with phase correction;

(iv) applying phase correction through a double-filtering procedure, applying a filter on the original data and then another filter, with identical characteristics, to the filtered signal, but reverting the direction of the signal;

(v) obtaining the envelope of the resulting signal, using a rectifying process (absolute value) and again filtering at low frequency;

(vi) finding the maximum width in the envelope;

(vii) finding the first minimum of the signal from the maximum found;

(viii) finding the maximum positive grade from the first minimum found and before reaching the mill's vertical; and

(ix) obtaining from the angular axis the position of the maximum positive grade, thus defining the angular position of the load shoulder with respect to the mill's vertical axis.

36. The method of claim 24, wherein the step of estimating, on line, the volumetric filling of dynamic load comprises the steps of:

obtaining the value of the angle of load foot θ_P;

obtaining the value of the angle of the load shoulder θ_H;

obtaining the revolving speed expressed as the critical speed fraction ϕ_C;

obtaining the volumetric filling of the total dynamic load J_C based on the equation:

$$J_C\% = \frac{\pi + A \cdot \theta_P \cdot (B + C \cdot \phi_C) - D \cdot \phi_C \cdot \theta_H}{E \cdot \theta_P}$$

where A, B, C, D and E are constants that is determined experimentally during the system start-up and calibration stages through various inspections of the condition of the load inside the mill, that depend on constructive and operational aspects of the mill and on the wear extent of its lining, wherein said inspections comprise geometrically measuring the volume occupied by the total load when the mill is stopped, and with the data obtained from the different inspections carrying out a quadratic error minimizing procedure to obtain the value of each constant.

37. The method of claim 26, wherein the step of determining the dynamic volumetric grinding ball load comprises the steps of:

(i) determining the volumetric filling of total dynamic load J_C;

(ii) calculating the dynamic volumetric ball load J_B, based on the equation:

$$Pot = A_1 \cdot J_B \cdot K_P \cdot F_V \cdot F_D \cdot F_C;$$

where: Pot is the instantaneous electric power consumed by the mill;

A_1 is a constant that is determined experimentally during the system start-up and calibration stages through inspections of the condition of the load inside the mill;

F_V is the mill speed factor, that is determined based on the equation:

$$F_V = \phi_C \cdot (1 - \frac{0.1}{2^{(9-10 \cdot \phi_C)}});$$

F_D is determined by the equation:

$$F_D = d_{eff}^{\ 2.5} \cdot L_{mol};$$

where d_{eff} is the mill's mean internal diameter that is effectively used in the grinding process, having a value that varies in time and depends on the processed tonnage accumulated by the mill;

L_{mol} equals the effective length of the mill;

F_C is the internal load factor calculated through the equation:

$$F_C = 1 - A_2 \cdot J_C;$$

where A_2 is a constant that is determined experimentally during the system start-up and calibration stages through inspections of the condition of the load inside the mill; and

K_P is a power constant that is determined experimentally during the system start-up and calibration stages through various inspections of the condition of the load inside the mill, including from the inspection of the volumetric filling that uses balls after a mill wash procedure, where said inspections to determine constants A_1, A_2 and K_P are obtained from measurements of the volume used by the balls when the mill is stopped, for which the mineral inside the mill is discharged prior to stoppage, and with the data obtained from the different inspections a mean quadratic error minimization procedure is performed to obtain the value of each constant.

38. The method of claim 36, wherein the step of determining the dynamic volumetric filling of grinding balls comprises the steps of:

(i) calculating the total dynamic volumetric load filling J_C;

(ii) calculating the dynamic volumetric ball load J_B, based on the equation:

$$Pot = A_1 \cdot J_B \cdot K_P \cdot F_V \cdot F_D \cdot F_C;$$

where: Pot is the instantaneous electric power consumed by the mill;

A_1 is a constant that is determined experimentally during the system start-up and calibration stages through inspections of the condition the load inside the mill;

F_V is the mill speed factor, that is determined based on the equation:

$$F_V = \phi_C \cdot \left(1 - \frac{0.1}{2^{(9-10 \cdot \phi_C)}}\right);$$

F_D is determined by using the equation:

$$F_D = d_{eff}^{\ 2.5} \cdot L_{mol};$$

where d_{eff} is the mill's mean internal diameter that is effectively used in the grinding process, having a value that varies in time and depends on the processed tonnage accumulated by the mill;

L_{mol} equals the effective length of the mill;

F_C is the internal load factor calculated through the equation:

$$F_C = 1 - A_2 \cdot J_C;$$

where A_2 is a constant that is determined experimentally during the system start-up and calibration stages through inspections of the condition of the load inside the mill;

K_P is a power constant that is determined experimentally during the system start-up and calibration stages through various inspections of the condition the load inside the mill, including from the inspection of the volumetric filling that uses balls after a mill wash procedure, where said inspections to determine constants A_1, A_2 and K_P are obtained from geometrical measurements of the volume used by the balls when the mill is stopped, for which the mineral inside the mill is discharged prior to stoppage, and a mean quadratic error minimization procedure is performed to obtain the value of each constant.

39. The method of claim 27, wherein the step of determining the dynamic volumetric mineral filling is obtained as an arithmetic difference between the dynamic volumetric load filling and the dynamic volumetric ball load.

40. The method of claim 28, wherein the step of determining the apparent density of the load comprises the steps of:

(a) obtaining the mineral mass from the dynamic volumetric mineral filling and the known density of the mineral;

(b) obtaining the ball mass from the dynamic volumetric ball load and the known density of the balls;

(c) obtaining the total mass of the mass as the sum of the mass of the mineral and of the balls; and

(d) obtaining the apparent density of the load and a coefficient between the total mass of the load and the total volumetric filling of the load.